

REMARKS

The Preliminary Amendment filed November 30, 2001, requested the Office to amend claim 66 and provided a marked-up amended version of claim 66. Any inconvenience to the Office is sincerely regretted. However, owing to clerical oversight, no clean copy of amended claim 66 was also provided. This minor oversight is rectified herewith by the filing of an amended claim 66 in proper form. The marked-up version of claim 66 filed November 30, 2001 is superseded by the version filed herewith which differs from the earlier version so that no clean copy of the November 30, 2001 version appears necessary.

In this amendment, claims 2-6, 9 and 13-14 are canceled and claims 1, 7, 11-12 and 66 are amended. New claims 84-119 are added particularly pointing out and distinctly claiming the subject matter of the invention.

The Invention of Claim 1

The invention as now claimed in amended claim 1 provides a concentric spectrograph comprising a concave diffraction grating and a coaxial convex field lens having planar and convex surfaces. The convex surface faces and is concentric with the grating concave surface. The spectrograph has an entrance port to introduce incident polychromatic light to the field lens at a location on the planar surface of the lens which is out of the meridian plane of the grating and on one side of the meridian plane. The

meridian plane is a plane containing the grating optical axis and extending perpendicularly to the grating grooves. An exit port is located to receive a desired order of diffracted light emerging from the lens planar surface at a location out of the meridian plane on the other side of the meridian plane from the incident light, without significant mixing with adjacent orders of diffracted light.

In use, the grating, as is well known in the art, diffracts incident light into a number of spatially dispersed orders. The exit port is positioned to receive a desired order, for example, the negative first order which is preferred for its intensity and closeness to the optical axis. In conventional concentric spectrographs, where light is introduced to and collected from the lens planar surface, at locations on the meridian plane, significant stray light problems occur.

The present invention identifies one source of these problems as being contamination of the output image with scattered light from adjacent diffraction orders that may reach the exit port traveling along indirect paths within the instrument. The invention recognizes, for the first time, that portions of the diffracted light orders can reflect back from the convex lens surface toward the diffraction grating where they will undergo a second diffraction. In conventional concentric spectrographs, this twice-diffracted light may reach the exit port.

By offsetting both the location of incidence from the entrance port and the location of emergence of the diffracted light to the exit port, as defined in amended claim 1, the invention enables this twice-diffracted stray light to be rejected.

WO 90/02928 ("Lobb")

A reference cited in a search report received on a counterpart European application, Sira Ltd.'s international publication WO 90/02928, inventor Lobb, ("Lobb" herein after) discloses an imaging spectrometer useful, for example, for scanning the Earth's surface (*last complete paragraph on page 2 of the specification*). Figs. 1, 2 and 4 of the drawings are orthogonal to the grating lines and apparently include the optical axis. Accordingly, Figs. 1, 2 and 4 are meridian plane views. Fig. 4 is a modified embodiment. Fig. 3 is a view parallel to the grating lines, i.e. perpendicular to Figs. 1-2 and 4.

The structure of the device shown in Figs. 1-3 is described at page 5 line 4 to page 6, line 7 from the bottom. Relevant description of the alternative embodiment of Fig. 4 appears at page 10, line 3 from the bottom to page 11, line 8. Stray light rejection is discussed at page 12, line 20 to page 14, line 4.

The Lobb spectrometer comprises an entrance aperture 116, a planoconvex field lens, called a refracting corrector 104, which receives light incident at entrance aperture

116, and a concave reflecting diffraction grating 106 facing the convex surface of corrector 104. Light received by diffraction grating 106 from corrector 104 is output to an image or spectrum plane 112 through an unlabeled exit port shown only in Fig. 1. The convex surface of corrector 104 and the concave surface of grating 106 are concentric with a center of curvature at or near the spectrum plane 112 (*page 6, lines 10-13 and 6-8*) where the image is received by an instrument such as an area array detector 114.

Lobb's entrance aperture 116 is shown as traversing the meridian plane and the optical axis in Fig. 1. In Fig. 3, when read with the description at page 6, paragraph 4, the entrance aperture can be seen to be longitudinally extended on either side of the spectrometer optical axis, parallel to the grating lines. In Fig. 4 the entrance aperture, in object plane 104, is rotated through 90°, by means of a prism 400, to separate the object plane 102 from the spectrum (image) plane 112. The Fig. 4 entrance aperture may be understood from Fig. 3 to be longitudinally extended, parallel to the grating lines, on either side of the meridian plane. The meridian plane is, in Fig. 3, the plane perpendicular to the paper on the optical axis 210. In Fig. 4., the meridian plane is the plane of the paper. The entrance aperture can be slit-shaped or comprise two or more slits (*page 7, 3 lines from bottom to page 8, line 1*).

For optimal results, Lobb places the center of the entrance aperture at the center

of curvature of grating 106 and the convex surface of corrector 104 (*page 9, last three lines*). This is the point referenced 202 in Fig. 2. Since the center of curvature lies on the optical axis and the meridian plane, the entrance aperture is in optimal configurations these entities are be symmetrically centered in the entrance aperture.

Clearly, Lobb's spectrometer does not meet the requirements of applicant's amended claim 1 that the entrance port should introduce incident polychromatic light to the lens planar surface at a location on the lens planar surface *out of* the meridian plane on the one side of the meridian plane. For this reason alone, the invention of amended claim 1 is clearly and patentably distinguished from Lobb.

Lobb's exit port, or image plane 112, Figs. 3 and 4, is also extended on either side of the spectrometer optical axis, parallel to the grating lines. Therefore, Lobb's spectrometer furthermore does not meet the requirements of applicant's amended claim 1 that the exit port should receive diffracted light from the lens planar surface at a location on the lens planar surface *out of* the meridian plane on the other side of the meridian plane. The invention of amended claim 1 is further clearly and patentably distinguished from Lobb for this additional reason.

Nor does Lobb's spectrometer meet the requirement of amended claim 1 that the exit port receive an order of diffracted light without significant mixing with adjacent

orders. Lobb takes no steps to this end and the extended area exit port required to deliver light to image plane 112 , as shown in Lobb's drawings, clearly will not discriminate one diffraction order from others. This is because image plane 112 extends along the meridian plane, in a direction transverse to the grating lines, in a position where multiple diffraction orders will be received. The invention of amended claim 1 is still further clearly and patentably distinguished from Lobb for this additional reason.

Not surprisingly, with its extended entrance and exit ports, Lobb's spectrograph suffers from significant stray light problems. These are discussed at page 12, line 20 to page 13, line 11 and include scatter from optical surfaces and reflections from the detector. As discussed in more detail in applicant's specification (*e.g. at column 2, lines 3-8 and column 8, lines 8-67*), and avoided by applicant's invention, light reaching the convex surface of corrector lens 104 can be reflected back to grating 106 and further diffracted whereupon second order and other images can be received at the exit port, contaminating the image.

Lobb's stray light difficulties are such as to require the complication of complementary ghost image removal by signal processing (*page 13, lines 22-25*), success of which is predicated upon employing a slit-shaped entrance aperture at the optical axis (*page 13, lines 17-18*). In view of the uncertainty of this measure, the utility of which is dependent upon the quality of the ghost image, Lobb also proposes the more drastic

measure of using only one side of the grating to avoid back diffraction of reflections from the detector surface (*page 13, line 26 to page 14, line 4*) to the exit port. In addition to its other drawbacks, This measure complicates the device, reduces the intensity of the output image and may not be effective for rejection of twice-diffracted second order images.

Clearly, Lobb does not remotely suggest applicant's spectrograph as claimed in amended claim 1 which elegantly solves stray light problems by offsetting both the entrance port and the exit port from the meridian plane and by positioning the exit port to receive one order of diffracted light without significant mixing with adjacent orders. Lobb neither recognizes that twice-diffracted second order light may contaminate a first order image, nor provides a solution to the problem.

By offsetting the entrance and exit apertures, and taking the other measures set forth in amended claim 1, applicant avoids introducing light normal to the grating. Consequently, the grating can be fully illuminated, for optimal image intensity, while stray light problems are avoided.

Accordingly, applicant's invention, as now claimed in claim 1 is believed clearly and patentably distinguished from Lobb or any other reference known to applicant.

Furthermore, one skilled in the art will see that applicant's preferred embodiment, as shown in the drawings, is quite unlike Lobb's embodiments, with respect to the construction of the entrance and exit ports, and will therefore expect a different result to be obtained, as indeed it is. Thus, Lobb's preferred entrance port, slit 102, Figs. 3 and 4, extends for more than half the diameter of lens 104, as shown in Fig. 3. In contrast, applicant's preferred entrance port 205, 305, 405, 475 or 505, as consistently shown in Figs. 5-7 and 9-13, is quite small in relation to field lens 215, 315, 415 or the lens of Fig. 13.

Comparably, Lobb's preferred exit port, or image plane 112, as shown in Figs. 3 and 4, has a substantial, two-dimensional extent equivalent to a major portion of the right-hand half of lens 104, looking toward grating 106. Again in contrast, applicant's preferred exit port 211, 311, 411, 476, 505 or 575, as consistently shown in Figs. 5-7 and 9-13 of applicant's drawings, is also quite small in relation to field lens 215, 315, 415 or the lens of Fig. 13. Applicant's preferred exit port has a narrow elongated shape, is positioned to receive one diffraction order without mixing with others and is overall quite different from the much larger extended area exit port required by Lobb to receive exiting light into image area 112.

Lobb's slit 102 and image plane 112 would clearly be difficult, if not impossible to relocate in accordance with the requirements of amended claim 1, even were the art to

contain a suggestion to do same, which the art known to applicant does not.

Attempting to relocate slit 102 or image plane 112 to be on one or the other side of the meridian plane of Lobb's spectrograph would require changes not suggested and contrary to Lobb's objectives. Clearly, Lobb neither taught nor contemplated applicant's claimed invention or the benefits to be obtained therefrom .

Independent Claims 66, 106, 112 and 117

Independent claims 66, 106, 112 and 117 are also believed clearly and patentably distinguished from Lobb or any other reference known to applicant for reasons similar to those explained with regard to amended claim 1.

Dependent Claims

Claims 7-8, 11-12 and 84-105 depend either directly or indirectly from base claim 1, claims 107-110 depend from base claim 106, and claims 113-116 depend from base claim 112. Dependent claims 7-8, 11-12, 84-105, 107-110 and 113-116 are therefore believed allowable with their respective base claims for the reasons that the base claims are believed allowable. Dependent claims 7-8, 11-12, 84-105, 107-110 and 113-116 are furthermore clearly and patentably distinguished from the art of record, and therefore allowable, by the additional meaningful limitations they recite.

More particularly, claim 84 specifically recites that the exit port is located to

receive first order diffracted light without significant mixing with second order diffracted light or zero order reflected light , which is not remotely suggested by Lobb, or any of the art of record in the original application.

Claim 86 specifically recites that the entire cross-sectional area of each entrance or exit port is located at a distance from the meridian plane, which is not remotely suggested by Lobb, or any of the art of record in the original application.

Claim 94 clearly recites multiple pairs of entrance and exit ports, and claim 95 specifies that the spectrograph comprises at least two paired entrance and exit ports, neither of which subjects is shown or suggested by Lobb, or any of the art of record in the original application.

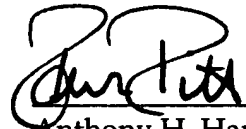
Moreover, Claim 103 specifically recites that input light is incident upon the grating at a non-perpendicular angle and that incident light fills the grating area. Claim 104 recites that the entrance and exit ports are laterally displaced on opposite sides of a plane perpendicular to the meridian plane neither of which subjects is shown or suggested by Lobb, or any of the art of record in the original application.

In view of the above amendments and the discussion relating thereto, it is

respectfully submitted that the instant application, as amended, is in condition for allowance. Such action is most earnestly solicited. If for any reason the Examiner feels that consultation with Applicant's representative would be helpful in the advancement of the prosecution, he is invited to call the telephone number below for an interview.

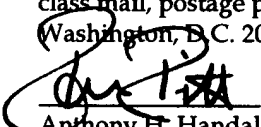
Respectfully submitted,

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I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail, postage prepaid, in an envelope addressed to: Assistant Commissioner for Patents, Washington, D.C. 20231, on May 22, 2002


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"VERSION WITH MARKINGS TO SHOW CHANGES MADE"

1. (twice amended) A concentric spectrograph comprising:

a diffraction grating having an optical axis, a meridian plane, ~~and a grooved~~ concave surface and a set of parallel grating grooves on said concave surface, said meridian plane containing the grating optical axis; and extending perpendicularly to the parallel grooves ~~and having a first and second sides, the first side being a volume residing above the meridian plane and a the second side being a volume residing below the meridian plane;~~

a field lens having a ~~substantially~~ planar surface, a convex surface; and an optical axis, wherein said lens convex surface faces and is concentric with said grating concave surface, ~~and~~ said optical axes of said grating and said lens are ~~substantially coaxial or parallel~~ coincident and said planar surface extends perpendicularly to said lens optical axis;

an entrance port located ~~out of said meridian plane on said first side so that to~~ introduce incident polychromatic light ~~is introduced~~ to the lens planar surface at a location on said lens planar surface out of said meridian plane and on said ~~first~~ one side of said meridian plane; and

an exit port located to receive a non-zero order of diffracted light emerging from said lens planar surface at a location out of said meridian plane on ~~said second~~ the other side of the meridian plane from the incident light, ~~for receiving one order of diffracted light~~ without significant mixing with adjacent orders of

diffracted light.

7. (amended) The spectrograph of claim 1 wherein said ~~primary~~ entrance port and said ~~primary~~ exit port are located at ~~substantially~~ the same perpendicular distances from said meridian plane.

8. (amended) The spectrograph of claim 1 ~~wherein:~~
~~said entrance port is for receiving polychromatic light from a source, said~~
~~spectrograph further comprising: a housing enclosing the grating and lens for~~
~~preventing reducing stray light from contaminating said polychromatic light in said~~
~~housing contamination.~~

11. (amended) The spectrograph of claim 1 further comprising a reflective surface between said ~~primary~~ entrance port or said exit port and said lens.

12. (amended) The spectrograph of claim 11 wherein said reflective surface is planar and has an axis normal to said reflective surface, said axis forming an angle with said grating optical axis, said angle optionally being about 45 degrees.

66. (amended) A method for dispersing light comprising:
passing polychromatic light through an entrance port located ~~substantially~~ on a first

side of and at a perpendicular distance from a meridian plane of a concave diffraction grating, said meridian plane containing the grating optical axis and extending perpendicularly to the parallel grooves;

directing said polychromatic light with a lens toward said grating so that said light is incident on said grating ~~at least at said meridian plane;~~

diffracting said light with said diffraction grating, thereby dispersing said light; and

imaging said dispersed light with said lens at an exit port located ~~substantially~~ on a second side of said meridian plane for receiving ~~an a non-zero~~ order of diffracted light ~~that maximizes throughput and minimizes astigmatism without significant mixing with adjacent orders of diffracted light.~~